

PUERTO RICO AND VIRGIN ISLANDS  
PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 42* and *Technical Paper No. 53*

Fifth Progress Report  
1 July 2001 through 30 September 2001

Hydrometeorological Design Studies Center  
Hydrology Laboratory

Office of Hydrologic Development  
U.S. National Weather Service  
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The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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### 1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency analysis for Puerto Rico and the Virgin Islands. Current precipitation frequency studies for the area are contained in *Technical Paper No. 42* "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau 1961) and *Technical Paper No. 53* "Two- to ten-day rainfall for return periods of 2 to 100 years in Puerto Rico and Virgin Islands" (Miller 1965). The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual and seasonal precipitation frequencies for durations from 5 minutes to 10 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Puerto Rico and Virgin Island study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14. They will also be made available on the internet using web pages with the additional ability to download digital files.

The study area covers Puerto Rico and the U.S. Virgin Islands of St. Thomas, St. John and St. Croix. The study area is divided into 7 near-homogeneous climatic regions for analysis (Figure 1). Factors considered in defining the regions include 1) season(s) of highest precipitation, 2) type of precipitation (e.g., general storm, convective, tropical storms or hurricanes, or a combination), 3) climate, 4) topography and 5) homogeneity of these factors in a single area. The designated regions in this study have been confirmed by homogeneity tests.

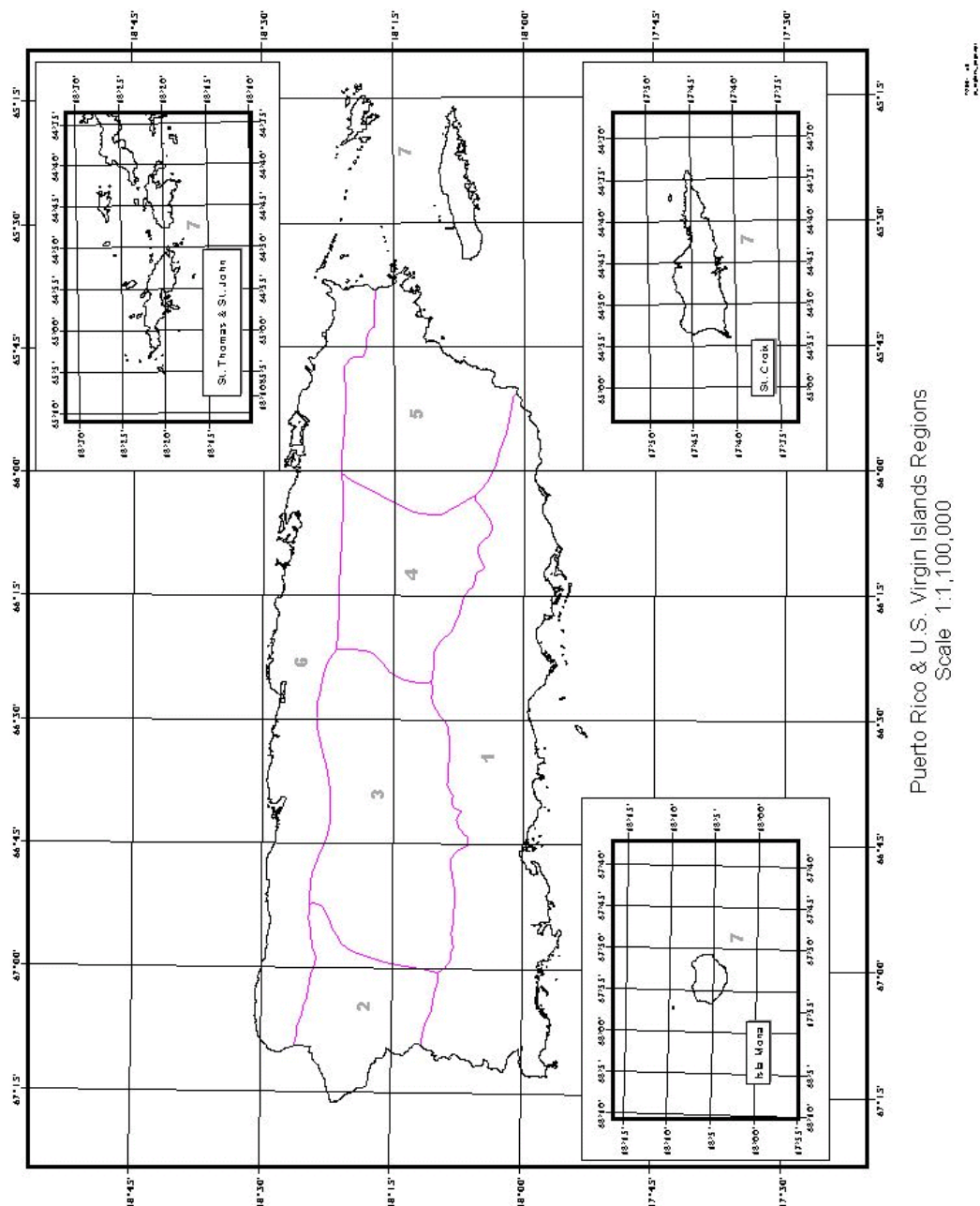


Figure 1. Puerto Rico Precipitation Frequency study area and region boundaries.

## 2. Highlights.

Data through December 2000 are currently being quality controlled and added to both the hourly and daily datasets and to the n-minute dataset through May 1998. NCDC is also making available their TD3206 daily dataset, which is primarily data before 1949. This data will be quality controlled and added to the dataset. Additional information is provided in section 4.1, Update of Data Collection and Quality Control.

Work on the Internet-based Precipitation Frequency Data Server has continued for the Semiarid Southwestern United States Precipitation Frequency Project. In particular, areal calculation of precipitation frequencies has been modified to allow user-entered longitude/latitude points to establish the size of the area. An improved web page framework has also been developed. The Precipitation Frequency Data Server will accommodate future studies including the Puerto Rico Study. Additional information is provided in Section 4.2, Update of Precipitation Frequency Data Server.

Significant progress was made on the technology review we initiated in the previous reporting period. (See 4<sup>th</sup> Progress Report for the Puerto Rico and Virgin Islands Study, August 2001; Section 5, Issues.) In an L-moment Applications Working Group, a panel of 3 independent experts confirmed our current statistical analysis procedures with suggested modifications. Finally, discussions held between HDSC and Spatial Climate Analysis Center determined that it is highly likely that Parameter-elevation Regressions on Independent Slopes Model (PRISM) technology can and will be adapted for precipitation frequency studies. Additional information is provided in Section 4.3, Update of Technology Review.

### 3. Status.

#### 3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percentage completed per task.

Puerto Rico study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [90%]

- Daily
- Hourly
- N-minute

L-Moment Analysis/Frequency Distribution for 1 hr - 10 days and 2 to 1000 yrs [70%]

- Daily
- Hourly
- N-minute

Algorithm/Data Plot [15%]

- Establish regions from spatial, topographic and meteorological variables
- Run L-moments for regional growth factors to generate dataset
- Create 2yr-24hr precipitation frequency index map
  - Format dataset
  - Review maps (i.e., station id's, discordancy, elevation, frequency values)
  - Review hand-drawn analysis
  - Perform digitization
  - Rasterization
  - Generate contour rasters for final map
- Create ratio maps - 2yr (1-12) hr/2yr 24hr, 2yr (2-60) day/2yr 24hr
  - Plotting
  - Review hand-drawn analysis
  - Perform digitization
  - Rasterization
- Create regional growth factor maps - (5-100) yr (1-12) hr, (5-100) yr 24hr, (5-100) yr (2-60) day

#### Precipitation Frequency Maps [10%]

- Create frequency maps for 1-hour to 60-day durations at return periods 2 to 1000 years (seasonal and annual maximum) by multiplying index map rasters and using appropriate regional growth factor and ratio map rasters
- Create maps and/or relations for durations smaller than 1 hour (5, 10, 15, 30 minute) using index map and appropriate conversion factors
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

#### Data Trend Analysis [10%]

- Analyze linear trends in annual maximums and variance over time
- Analyze shift in means of annual maximums between two time periods (i.e., test the equality of 2 population distribution means)

#### Seasonal Analysis [0%]

- Create graphs of percentage of precipitation maximums in each month of a year

#### Temporal Distributions of Extreme Rainfall [0%]

- hourly data assembled by quartile of greatest precipitation amount and converted to cumulative rainfall amounts for each region
- graphs of representative storm-types and seasons

#### Spatial Relations (Depth-Area-Duration Studies) [0%]

- analyze critical storms to determine depth-area-duration relations
- small-area, short-duration relations
- area-depth curves for areas  $<500 \text{ mi}^2$  and for  $>500 \text{ mi}^2$
- families of mass curves and area-depth curves as a function of duration and area size
- a smoothed set of curves to distinguish between convective, tropical and non-tropical storms (if appropriate)

#### Deliverables [10%]

- Write hard copy of Final Report
  - Maps of analyzed results
  - Graphical relations to obtain intermediate values
  - Seasonal variation
  - Depth-area distribution

- Temporal distribution of rainfall in extreme storms
- Implement peer review and interagency review
- Prepare data for web delivery
- Prepare documentation for web delivery
- Publish hard copy of Final Report

### 3.1.1 Data Collection and Quality Control.

Table 1 shows the total number of daily, hourly, 15-minute, and n-minute stations in the study area. We are in the process of adding data to the daily and hourly stations through December 2000 and to the n-minute dataset through May 1998. The digitized TD3206 daily dataset from NCDC for the time period before 1948 will also be added to the daily dataset as soon as it is available.

Table 1. Information on total daily, hourly and n-minute datasets through October 1998.

	Daily	Hourly	USGS 15-minute	N-minute
<b>No. of stations</b>	152	30*	103	1
<b>Longest record length (yrs) (Station ID)</b>	98 (66-0152, 66-2801, 66-4702)	32 (66-8812)	9 (67 stations have 9 yrs)	25 (66-8812)
<b>Average record length (yrs)</b>	45	23	8	25

\*2 of the stations included in this total have less than 1 year of data and therefore were not included in the average record length

### 3.1.2 Frequency Distribution Fitting Analyses:

This task evaluates and selects the frequency distribution which provides the best fit for the data. A comprehensive L-moment statistical analysis (Hosking and Wallis 1997) of goodness-of-fit has been done on both daily and hourly data through October 1998 for all durations and all regions to select a best-fit distribution.

### 3.1.3 Mapping Analyses.

HDSC continues to explore the possibility of using spatial interpolation tools such as the Parameter-elevation Regressions on Independent Slopes Model (PRISM). Discussions with the Spatial Climate Analysis Center have determined that, with the establishment of additional criteria, PRISM technology may be adapted to precipitation frequency data.

#### 3.1.4 Documentation and Publication.

The Puerto Rico and U.S. Virgin Island study results will be available on the HDSC Precipitation Frequency Data Server once mapping is complete and reviewed. The Precipitation Frequency Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. The Server is currently password protected and not publicly available. At present, all 50 states and Puerto Rico/Virgin Islands can be selected. Where studies are not yet concluded, information on existing precipitation frequency maps and how to obtain them is given.

#### **4. Progress in this Reporting Period.**

##### **4.1 Update of Data Collection and Quality Control.**

The quality control of the current daily, hourly and n-minute data through October 1998 is complete. No values in the entire dataset through October 1998 were found to be discordant.

The dataset will be updated in two ways. First, daily and hourly data through December 2000 are currently being quality controlled and added to the dataset. Second, a new TD3206 daily dataset, which consists primarily of data before 1949, will soon be made available through NCDC.

The threshold check and discordancy check will be updated with the 1999 - 2000 daily and hourly data and pre-1949 daily data. The quality control involves the threshold check, which verifies extreme values over a certain precipitation amount with nearby stations and other data sources, and the L-moment discordancy check, which flags stations with a discordancy value greater than or equal to 3.0 as suspicious or unusual. The new data will be extensively quality controlled, added to the dataset and included in precipitation frequency calculations. These updates will not change the number of stations in the study area but only increase the length of record at existing stations.

Daily stations that have 20 years or more of data and hourly stations that have 15 years or more of data are used in the L-moment analyses to determine precipitation frequencies for the Puerto Rico study. If stations have less than the appropriate number of years of data, they are available for storm analysis or other investigation. Table 3 shows the current number of daily and hourly stations used in the L-moment analysis for each region in the study area before the data update. These numbers may change with the updated datasets.

Table 3. Current daily and hourly stations used in L-moment analysis.

Region	Daily stations $\geq$ 20 years	Hourly stations $\geq$ 15 years
1	28	2
2	7	1
3	22	5
4	9	4
5	19	9
6	20	2
7	28	3
total	132	26

#### 4.2 Update of Precipitation Frequency Data Server

The Internet-based Precipitation Frequency Data Server (PFDS) continues to be developed, tested and enhanced. Most importantly, the areal calculation functionality has been modified to be more flexible and accurate. Unlike previous beta versions, the PFDS now uses a list of user-entered longitude/latitude points to calculate the area size and areal precipitation frequency estimates. Originally it was feared that the areal-calculations would require an unacceptable amount of time to compute, but with the new modifications, the calculation time is very fast.

Another important PFDS modification has been the initial development of a new web page framework. The new framework will better accommodate such items as Help, General Information, Feedback, Files for Downloading, Background Information, and Contact Information. The new framework will include a PFDS Users Guide as well as an on-line NOAA Atlas 14 Mini-Manual.

#### 4.3 Update of Technology Review

We have made significant progress on the technology review we initiated in the previous reporting period. (See 4<sup>th</sup> Progress Report for the Puerto Rico and Virgin Islands Study, August 2001; Section 5, Issues.)

#### 4.3.1 Data Collection and Quality Control

HDSC has defined a well-developed and efficient set of procedures for data collection and quality control. The procedures have been refined over time for extracting and quality controlling data from the National Climatic Data Center. The procedures and data formats are structured to fit efficiently into sequential processes for producing updated rainfall frequency estimates. We plan to continue using these procedures. HDSC plans to publish the final quality-controlled time series used in its analysis.

#### 4.3.2 Statistical Analysis

Based on recommendations during the previous quarter by independent experts, in this quarter we held detailed face to face discussions with David Goldman (U.S. Army Corps of Engineers), Ned Guttman (NOAA, National Climatic Data Center), and John Hosking (IBM). The discussions confirmed our general plan to use the statistical procedures described in *Regional Frequency Analysis: An Approach Based on L-Moments*, Hosking and Wallis, 1997. In their book, Hosking and Wallis discuss possible variations in specific procedures. HDSC will document and publish those areas where we have made a choice between possible alternatives. We have also decided to adopt the procedures described by Hosking and Wallis for assessing the accuracy of estimated values.

HDSC will use the *unbiased plotting-position estimators* unless we can demonstrate that careful use of the *biased plotting-position estimators* is more effective. During the next quarter we will proceed with the use of the unbiased estimators while conducting an assessment of the biased estimators. We do not expect this assessment to impact our schedule.

#### 4.3.3 Spatial Interpolation

HDSC held discussions in Corvallis with Oregon State University's Spatial Climate Analysis Service. In the previous reporting period we mentioned our concerns about legal issues relating to the use of their PRISM technology. Discussions suggest that these legal issues can be overcome. While PRISM has been accepted for spatial interpolation of other climatic parameters, it has not been proven in the analysis of rainfall intensity frequency duration estimates. Technical discussions and more detailed demonstrations of PRISM capabilities have convinced us that it is highly likely we will be able to use PRISM for spatial interpolation of the point estimates derived from regional analysis using L-moments. As a result, HDSC has entered into detailed discussions with the Spatial Climate Analysis Service to first conduct a final proof test of PRISM technology and then use the technology in our production process.

## **5. Issues.**

### **5.1 Personnel**

Dr. Lesley Julian has announced her retirement effective September 30 2001. Dr. Julian was a full time Federal Government employee and we have begun the process of seeking a replacement. Mr. Geoffrey Bonnin is now directly managing the HDSC.

## **6. Projected Schedule.**

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on in the next 2 quarters are also included in this section.

- Data Collection and Quality Control [November 2001]
- L-Moment Analysis/Frequency Distribution [December 2001]
- Algorithm/Data Plot [February 2002]
- Precipitation Frequency Maps [February 2002]
- Temporal Distributions of Extreme Rainfall [April 2002]
- Trend Analysis [December 2001]
- Seasonal Analysis [January 2002]
- Spatial Relations (Depth-Area-Duration Studies) [April 2002]
- Implement Precipitation Frequency Data Server [April 2002]
- Implement review by peers [May 2002]
- Write hard copy of Final Report [June 2002]
- Publish hard copy of Final Report [August 2002]

### **6.1 Data Collection and Quality Control.**

Daily and hourly station data through December 2000 and pre-1949 daily data will be added to the dataset and included in the precipitation frequency calculations. One additional year of n-minute data is available and will be added to the dataset. The tasks involved with data collection, formatting and quality control will take roughly 3 weeks for all regions in the Puerto Rico and Virgin Islands study area.

## 6.2 L-Moment Analysis/Frequency Distribution.

A comprehensive L-moment statistical analysis will be done on both daily and hourly completed datasets to provide the best quantile estimates. The tasks involved with the precipitation frequency analysis will take roughly one month for the Puerto Rico and Virgin Islands study area.

## 6.4 Precipitation Frequency Data Server.

Once the data and mapping are finalized, the precipitation frequency estimates for the Puerto Rico study will be available from the newly developed HDSC web-based Precipitation Frequency Data Server. The Precipitation Frequency Data Server will display precipitation frequency values, as well as intensity-duration-frequency (IDF) curves and tables. Eventually, all 50 states and Puerto Rico/Virgin Islands will be selectable from the opening U.S. map.

## References

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